California Environmental Protection Agency

Air Resources Board

Low Carbon Fuel Standard

"Pathways for Transportation Biofuels Derived from Organic Wastes and Agricultural Residues"

California Bioresources Alliance Symposium
Davis, California

June 3, 2014

Overview of Presentation

- **Background Information on LCFS**
- **ARB Pathways for Transportation Fuels**
  - **Baseline Fuels**
  - **Derived from Organic Wastes and Byproducts**
- **Staff Assessment of Waste-Derived Fuels in the Marketplace**
- **Case Study: Biofuel from Crop Residues**
- **Status of AB 1900: Biomethane Standards for Distribution in the Natural Gas Pipeline**
- **Conclusions**

Background Information

- **LCFS is a Component of AB 32, the Global Warming Solutions Act of 2006**
- **Requires 10 Percent Reduction in the Carbon Intensity (CI) of California's Transportation Fuels by 2020**
- **What is CI? Measures Aggregate Direct and Indirect GHG Emissions Over Lifecycle of Fuel**
  - **Expressed in g CO_2e / MJ**
- **Basis for Regulation: CIs for Diesel and Gasoline Over 2010-2020**
- **Performance-Based Incentives for Development of Low Carbon Fuels**

LCFS Lifecycle Analysis

Fuel's Well-to-Wheels Analysis for Carbon Intensity Determination

- **Direct GHG Emissions Referred to as Well-to-Wheels (WTW) Analysis**
  - **WTW has 2 Components, WTT and TTW**
  - **WTW = WTT + TTW**
- **CI is Expressed Per Unit of Fuel Energy (LHV)**
- **Mass Values for All GHG Emissions are Adjusted for Global Warming Potentials (GWP)**
  - **Example: CH_4 Emissions x 25 GWP = CO_2e**

ARB Pathways for Transportation Fuels

Two Baseline Fuel CIs in 2009 Lookup Table

Fuel	Source	Carbon Intensity (g CO_2e / MJ)
CARBOB (Gasoline)	Petroleum Crude	99.18
ULSD (Diesel)	Petroleum Crude	98.03

- **CIs of Petroleum-based Gasoline and Diesel Fuels are Used as Baseline Fuels to Measure Reductions in the CIs of California Transportation Fuels**
- **Transportation Fuels with Lower CI Generate Differential LCFS Credits**
- **Credits can be used to Meet Compliance, Banked, or Traded in the LCFS Market**

ARB Pathways for Transportation Biofuels

AD-based Pathways in Lookup Table

Fuel	Source	Carbon Intensity (g CO_2e / MJ)
CNG (Biomethane)	Landfill Gas	11.26
CNG (Biomethane)	Dairy Digester	13.45
CNG (Biomethane)	Food & Green Waste	-15.29
CNG (Biomethane)	Wastewater Sludge	(Proposed)

Biodiesel and Ethanol Pathways in Lookup Table

Fuel	Source	Carbon Intensity (g CO_2e / MJ)
Biodiesel	Used Cooking Oil	11.76 – 15.84
Renewable Diesel	Tallow	19.65 – 39.33
Ethanol	Byproduct Molasses	21.47 – 46.42

Staff Assessment of Waste-Derived Low Carbon Fuels in the Marketplace

- **Producers of Lower Carbon Transportation Fuels (Especially from Waste or Byproduct Resources) have Potential to Generate LCFS Credits**
  - **Small or No Indirect Land Use Change (LUC) Consideration**
  - **Lifecycle Assessment Credit for Avoided Landfilling / Flaring / or Disposal of Organic Waste, and for Electricity Export**
  - **Lower Energy Use (Example: Waste Heat Recovery from ICE)**
- **Expect Credits to Become More Valuable as Compliance CI for Gasoline and Diesel and Substitutes Becomes More Stringent in Target Year**
  - **CI (g CO_2e/MJ) for ULSD in 2014: 96.56 in 2020: 88.23**
  - **CI (g CO_2e/MJ) for CARBOB in 2014: 97.47 in 2020: 89.06**

Staff Assessment of Waste-Derived Low Carbon Fuels in the Marketplace

- **Example: 100 MGD POTW Producing Biomethane (Suggested CI = -26.28 g CO_2e/MJ)**
  - **Model 30% Allocation of 350,000 scf CH_4 / day for Transportation Fuel Use**
  - **Generates 42 Metric Tons of LCFS Credits per Day, and 4,400 RFS2 RINS per Day**
  - **LCFS Credit Trades Valued at $40 / Metric Ton, and $0.75 / RIN (Staff Estimate)**
  - **$1,700 / day ($615,000 / year) Additional Revenue from LCFS Credits**
  - **$3,300 / day ($1,200,000 / year) from RFS2 RINS**

Staff Assessment of Waste-Derived Low Carbon Fuels in the Marketplace

- **Example: 100 MGD POTW Producing Biomethane (Suggested CI = -26.28 g CO_2e/MJ)**
- **Model Allocation of 350,000 scf CH_4 / day to Transportation Fuel Purposes**
  - **$ 1,800,000 / year Total Revenues from LCFS Credits and RFS2 RINS**
  - **$ 500,000 / year Revenue from Product Gas**
  - **$ 2,300,000 / year Total Revenue**
  - **Comparatively, Projected Total Capital Costs for Biogas Upgrading Estimated to be $3,500,000***

    *** Projected Costs from Unison Solutions / Cornerstone for BioCNG System**
  - **Suggests CapEx Payback in 18 Months!**

Case Study
Biofuel Production from Crop Residues

- **Commercial Scale Biofuel Production from Cellulosic Crop Residues is a Reality**
- **For Example, Ethanol Production from Enzymatic Conversion of Cellulose in Corn Stover, and Sugarcane Straw / Bagasse**
- **Next Generation Cellulosic Ethanol Projects Under Construction in Brazil, Italy, and USA**
  - **For Example: GranBio in Alagoas, Brazil (Summer 2014)**
  - **20 Million Gallons Ethanol from Straw and Bagasse**
- **Preliminary WTW Indicates CI is "Very Low"**

Case Study: GranBio BioFlex Plant Ethanol Plant Under Construction

Photograph Courtesy of GranBio and Biofuels Digest

Case Study: GranBio BioFlex Plant Sugarcane Crop

Photograph Courtesy of GranBio and Biofuels Digest

Case Study: GranBio BioFlex Plant Ethanol Production from Straw Residue

Photograph Courtesy of GranBio and Biofuels Digest

Case Study: GranBio BioFlex Plant Straw Collection

Photograph Courtesy of GranBio and Biofuels Digest

Case Study: GranBio BioFlex Plant Straw Baling

Photograph Courtesy of GranBio and Biofuels Digest

Case Study: GranBio BioFlex Plant Straw Stock Piling

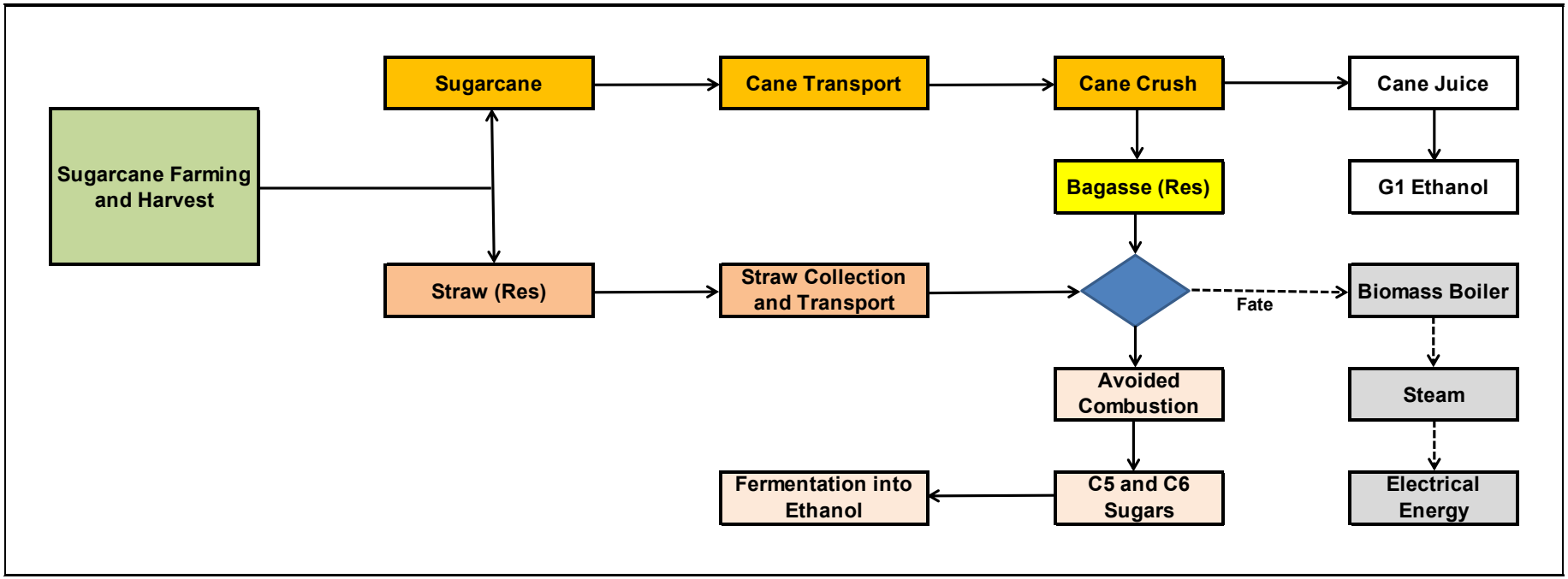
Photograph Courtesy of GranBio and Biofuels Digest

Case Study: GranBio BioFlex Plant Straw Transport to Ethanol Plant

Photograph Courtesy of GranBio and Biofuels Digest

System Boundary Considerations for Cellulosic Ethanol Pathway

LIFECYCLE ASSESSMENT OF CELLULOSIC CROP RESIDUES FOR BIOFUEL PRODUCTION



Status of AB 1900

- **Directed CPUC to Adopt Standards for Constituents of Concern (CoC) in Biomethane Injected into the Natural Gas Pipeline System**
  - **Standards to Protect both Public Health and Pipeline Safety and Integrity**
- **ARB and OEHHA Provided Recommendations on 12 Health-based Constituents from Publicly Available Information**
  - **Recommendations on Testing, Monitoring, and Recordkeeping**
- **CPUC Final Decision Directed Utilities to Modify Tariffs to Reflect Recommendations**

Conclusions

- **Producing a Lower Carbon Transportation Fuel is a Very Attractive Option**
- **Pathways and CIs for Organic Waste-Derived Fuels Available for Use Today**
- **LCFS Provides Additional Value to Developers**
- **LCFS Credits May Concurrently be used with EPA's RFS2 Program RINs**
- **Energy Producers can Contemplate Allocation of Biogas for Transportation Purposes (Example: POTWs and Landfill Operators)**
- **Favorable CIs for Next Generation Biofuels**

For More Information

- **ARB LINK TO LCFS HOMEPAGE**
  - http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

- **ARB STAFF CONTACTS**
  - **Kamal Ahuja**
    Air Resources Engineer, Fuels Evaluation Section (SSD)
    Phone: (916) 327-5604 Email: kahuja@arb.ca.gov

  - **Wes Ingram**
    Manager, Fuels Evaluation Section (SSD)
    Phone: (916) 322-3984 Email: wingram@arb.ca.gov